Telemetric tracing of blocked overloads in a new spine protector in human rehabilitation

Rafolt D[1], Saier T[2], Lanz P [2,4], Lehner P [2], Foidl N [2], Nepomucky T [1], Schneider T [1], Gallasch E [3]

[1] Center for Medical Physics and Biomedical Engineering, Medical University Vienna, Austria

[2] MADKEM Inc., Graz, Austria

[3] Department of Physiology, Medical University Graz, Austria

[4] Department of Trauma Surgery, Medical University Graz, Austria)

Abstract

After spinal cord injuries movements of the upper body must be restricted until damages like compressions or fractures are recovered completely. On the other hand as degeneration of unused tissue takes place very fast it is important that rehabilitation measures are taken as quick as possible in order to revive bones, tendons and muscles in a good state. Under this conflict patients very often feel highly unsure. Therefore we developed an new spine protector that is attached to the upper body to protect the patient against a repeated damage. Range of movements in direction of rotation, flexion, extension and lateral flexion is completely free unless adjustable limits are reached. Bigger amplitudes are restricted by absorbing higher forces into the protector. At the beginning of rehabilitation the limits are adjusted to a narrow range and during recovery time this limits are enlarged step by step. This gives a high secure feeling to the patient resulting in a more motivated training. In order to measure movement and overload forces during training and daily live situations we measured and transmitted 3D-angle and force signals form the protector to a telemetry recoding unit. Analysis of the data helps to find out optimum training tasks.

Keywords: human telemetry, spine protection, rehabilitation, force sensor.

Introduction

The background of this project is, that back protectors used in sports e.g. snowboarding or biking do not protect against overcritical movements of the upper body. They just protect against direct impact forces which are not responsible for the majority of bad injuries.

The largest epidemiological survey in spinal injuries shows, that the majority of such injuries are caused by spinal overextensions (96,1%).

Spinal overextensions are defined as exceeds of the physiological movement range limits between the vertebras. This type of injuries are specified by Magerl´s Type A (Compression), B (Distraction), C (Rotation) fractures. Rotational fractures are to be seen as the worst type of injuries, due to shearing forces, the spinal cord is prone to enormous damage. It is proven, that the percentage of neurologic damage rise from type A to type C fractures.

Even more this fact exists after an injury. Fractures on the vertebral body or damage on the vertebral disc or ligaments needs a period of immobilization. In a save range movements should be started as early as possible being aware that the healing process is not yet ready. During that time there could be a higher risk for a re-damage. Therefore rehabilitation at that state is done in the clinic under control of experienced physiotherapists. For this situation the use of the spine protector supports patient and therapists as they can perform exercises with a high level of protection against injury. An important feature is the adjustability of the range of movement (ROM).

Materials and Methods

In order to limit spine movements individually shaped forms are attached and fastened by belts to the shoulder and hip respectively and are connected to a mechanism located a the back shown in Fig.1. During movement the distance and orientation of the two cylinders will change. At both ends of a rode (connecting the cylinders) special shaped parts are fastened running inside the cylinders. In a defined range there is no restriction of movements. Exceeding this limits forces will arise in the rode that can be measured by strain gauges separately for all three planes. The gauges are connected to bridge amplifier. Orientation of the segments are measured by a twin-axis Goniometer SG150 and a single-axis Torsiometer Q150 (Biometrics Ltd. USA). All analog signals were converted to digital signals and transmitted to a notebook via bluetooth (BLE112, Bluegiga Technologies Inc.). Optional 2 channels for electromyography (EMG) can be added to the transducer system. The system is provided to use gyrometers instead of gonio- and torsiometers.

Fig.1: top: fixation of the protector to the body left: mechanism to limit combined 3D-movements; right: Strain gauge arrangement to measure torques in the horizontal, medial and frontal plane.

Results & Discussion

The new device was tested on 4 male healthy subjects. The limit of the movements were adjusted in the range of maximal voluntary movements. Higher extents are attainable applying external force input due to manipulation of a physician. Fig.2 shows experimental data for rotation movement with a 20° limit. The subject was fastened on a swivel chair and the shoulder was blocked. The external input was delivered to the chair using a lever equipped with a torque sensor and was compared to the measured torque in the protector. Without the protector the compliance of the body tissue a that level of rotation is 0,5 °/Nm. Using the protector system the compliance is reduced to 0,12 °/Nm. (Protection factor >4). For a high protection factor the proper adjustment of the protector to the body is essential. A good compromise between protection level and comfort level has to be found individually. The possibility of biotelemetry increases the safety level as movements and absorbed forces can be supervised online during exercises of the patient – even when the fixation of the device is not perfect.

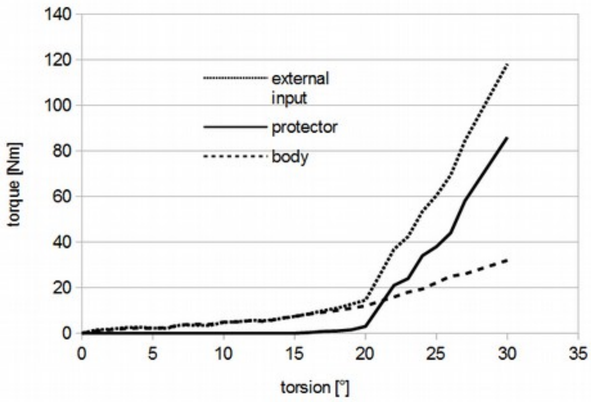

Fig.2: Torque [Nm] is plotted against torsion [°]. The load to the body is the difference between external input and torque absorbed in the protector.

Conclusions

With the new spine protector it is possible to improve rehabilitation procedures after spinal cord injuries. Moreover in disorders without a biomechanical crash for example osteoporosis, cancer and rheumatic disorder (eg morbus bechterew) the use of such a motion limiter could be beneficial.

Acknowledgements

Sensor development was supported by the Austrian Research Promotion Agency – FFG- Innovation check Nr. 838602.

Author's Address

Dietmar Rafolt, PhD
Center for Medical Physics and Biomedical Engineering
Vienna General Hospital
Währinger Gürtel 18-20, A-1090 Vienna
dietmar.rafolt@meduniwien.ac.at